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King et al.

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(54) METHOD OF ASSEMBLY OF SIX COLOR INKJET MODULAR PRINTHEAD

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(22) Filed: **Oct. 20, 2000**

(51) **Int. Cl.**[7] **B41J 2/16**; B41J 2/155

(52) **U.S. Cl.** **347/49**; 347/42; 347/19

(58) **Field of Search** 347/49, 42, 13, 347/19, 40, 12

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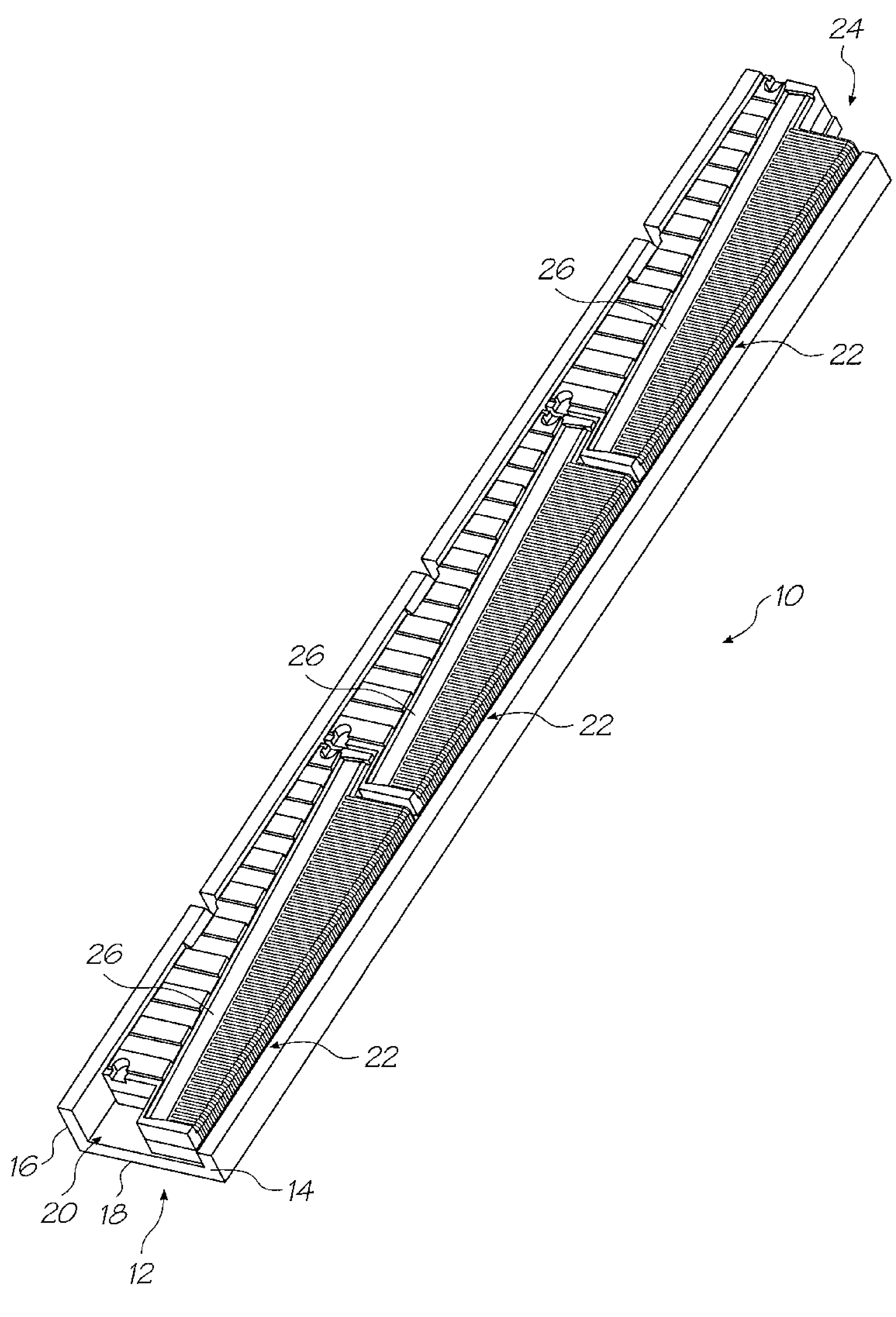
Primary Examiner—Lamson Nguyen

(57) **ABSTRACT**

A method of assembling a printhead which has a receiving member and a plurality of printhead modules arranged end-to-end in the receiving member includes, upon completion of manufacturing the receiving member, testing each bay of the receiving member in which a module will be received to determine a manufacturing offset from specification for that bay. A printhead module is selected having a manufacturing offset from specification which compensates for the offset of the bay of the receiving member for which it has been selected and the printhead module is then inserted into its associated bay of the receiving member.

7 Claims, 11 Drawing Sheets



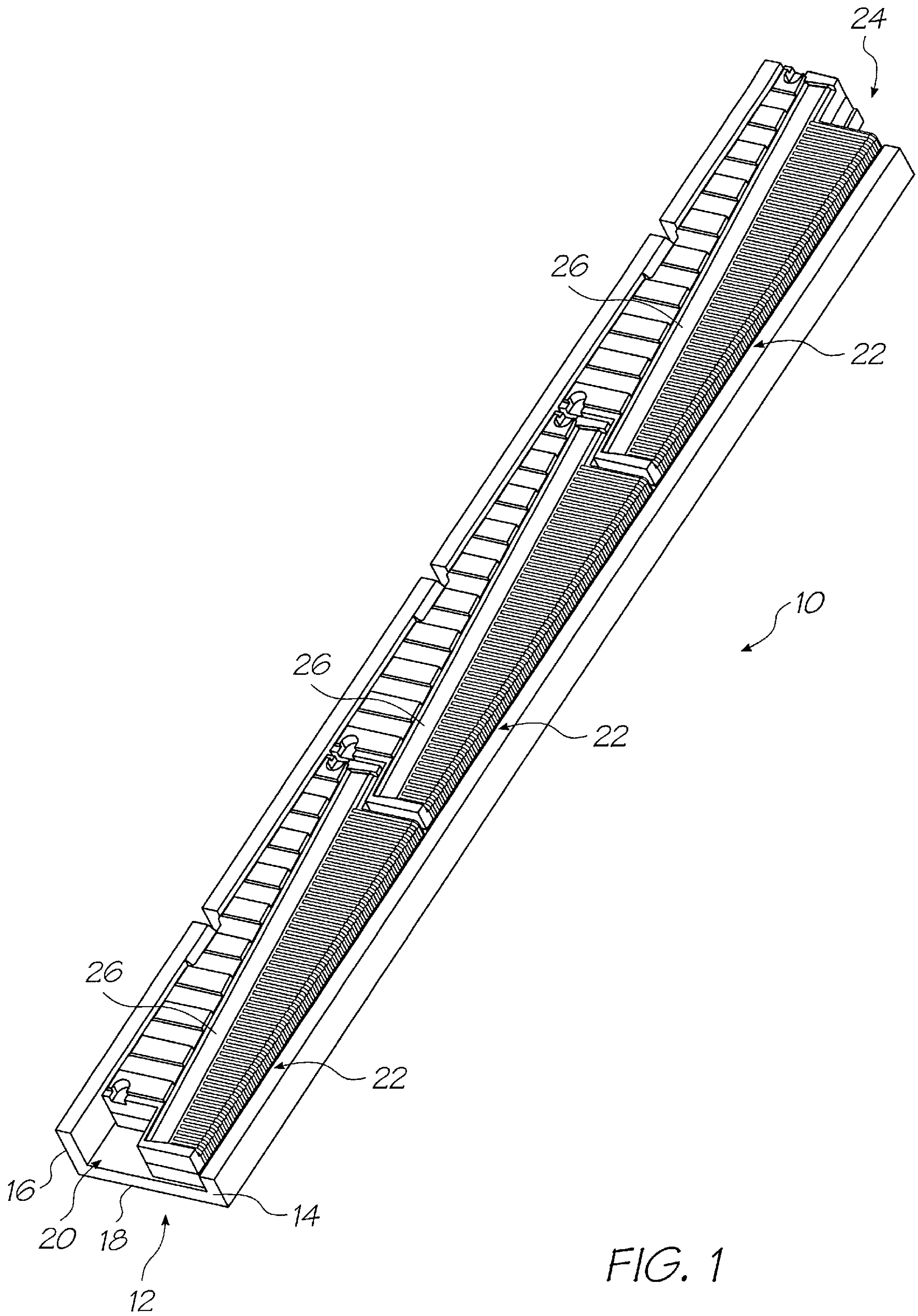


FIG. 1

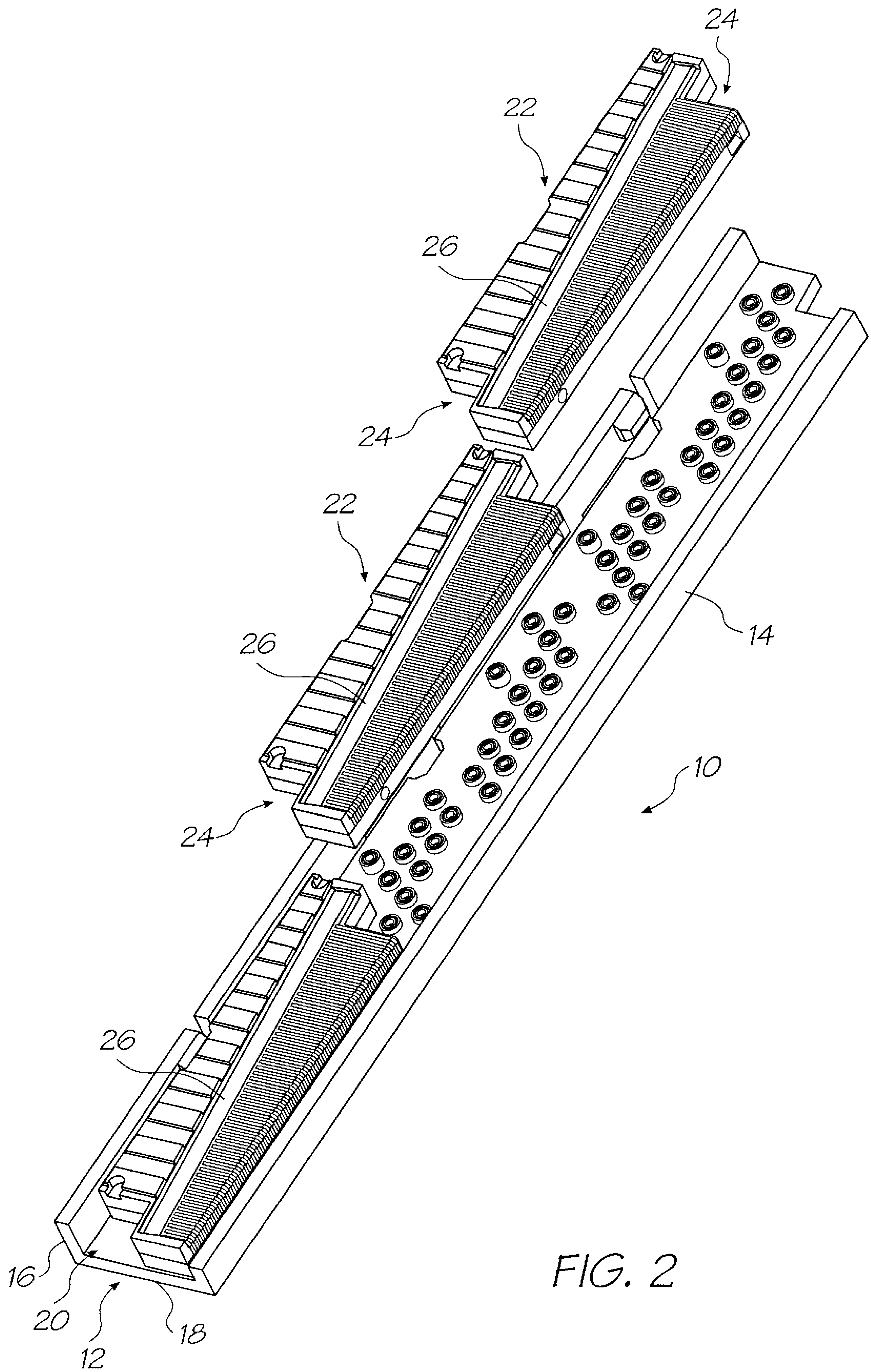


FIG. 2

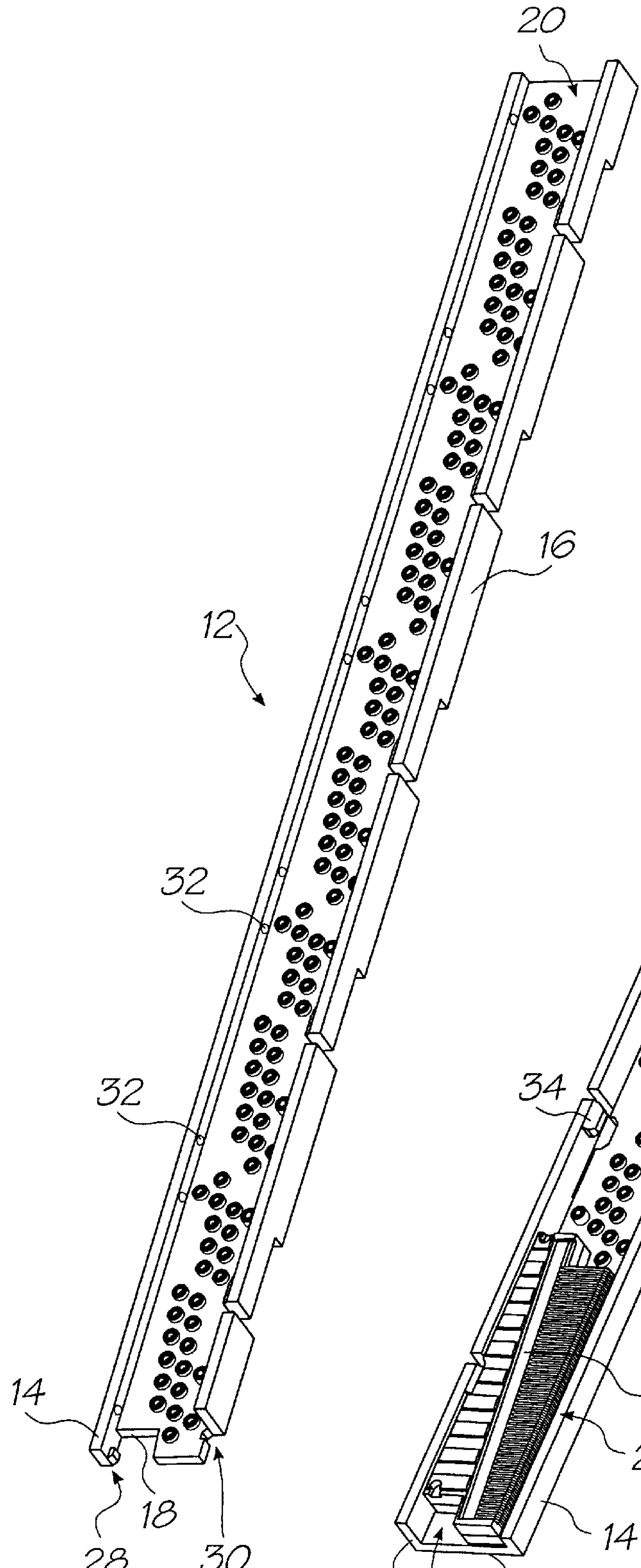


FIG. 4

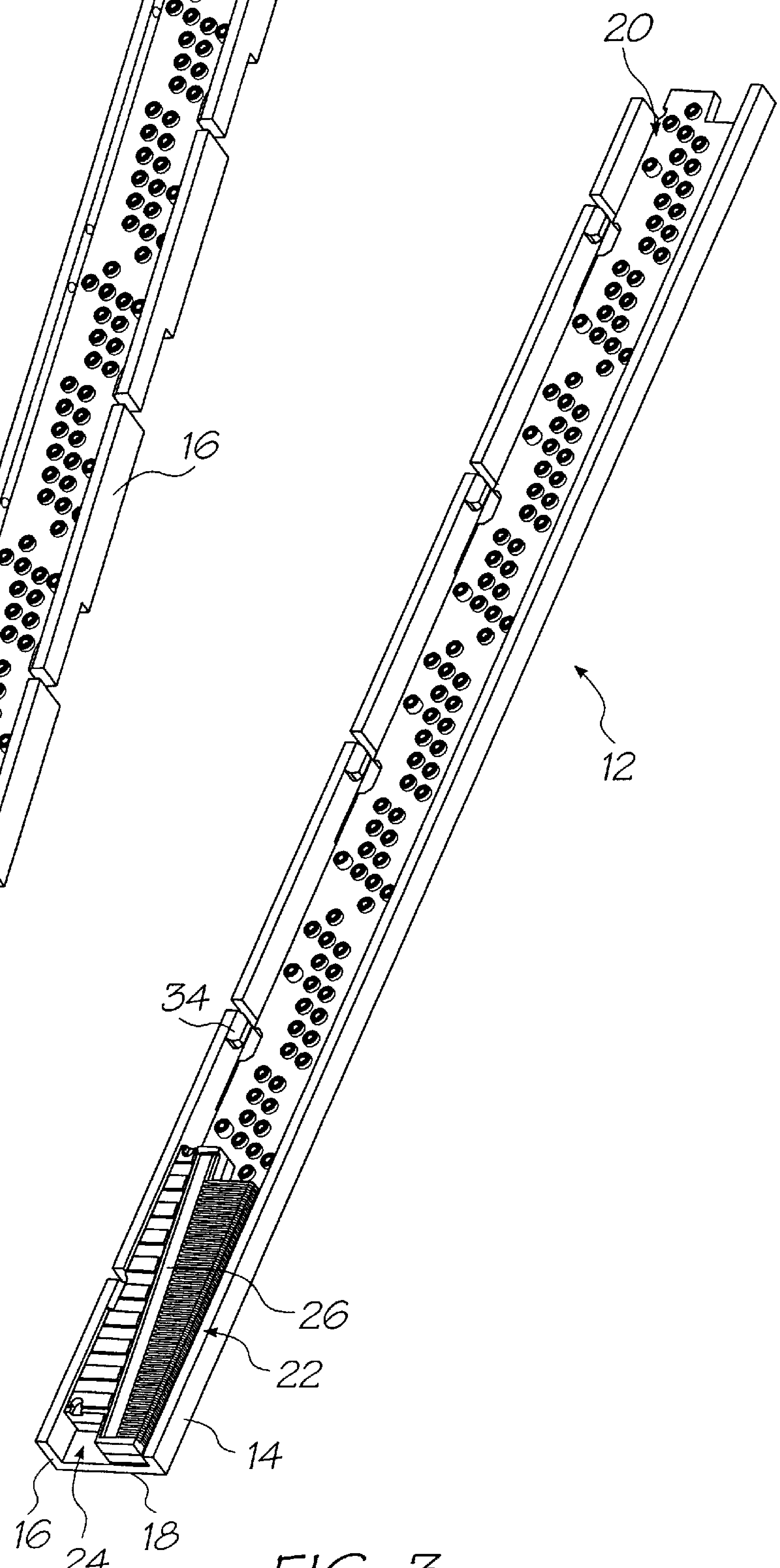


FIG. 3

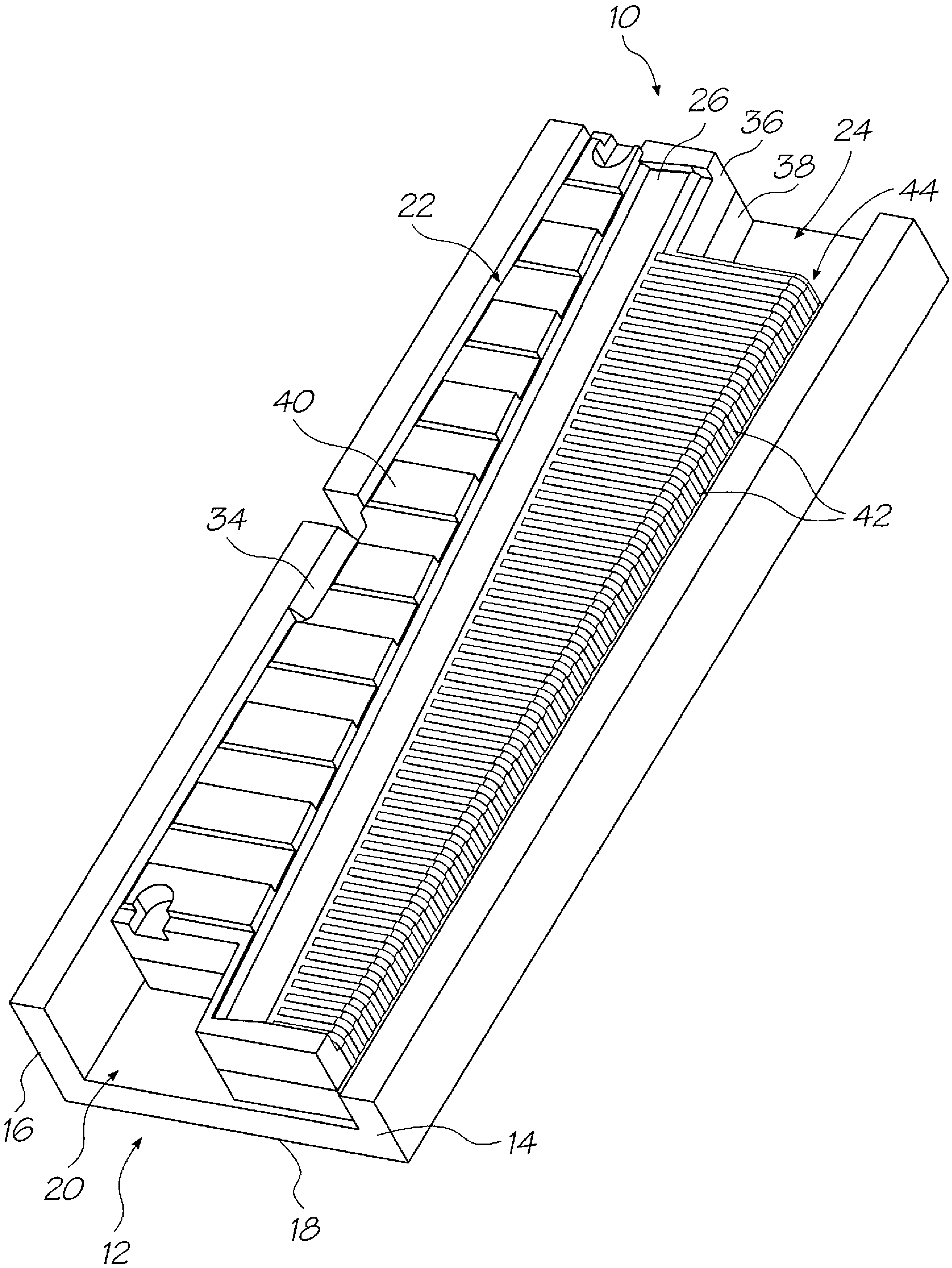
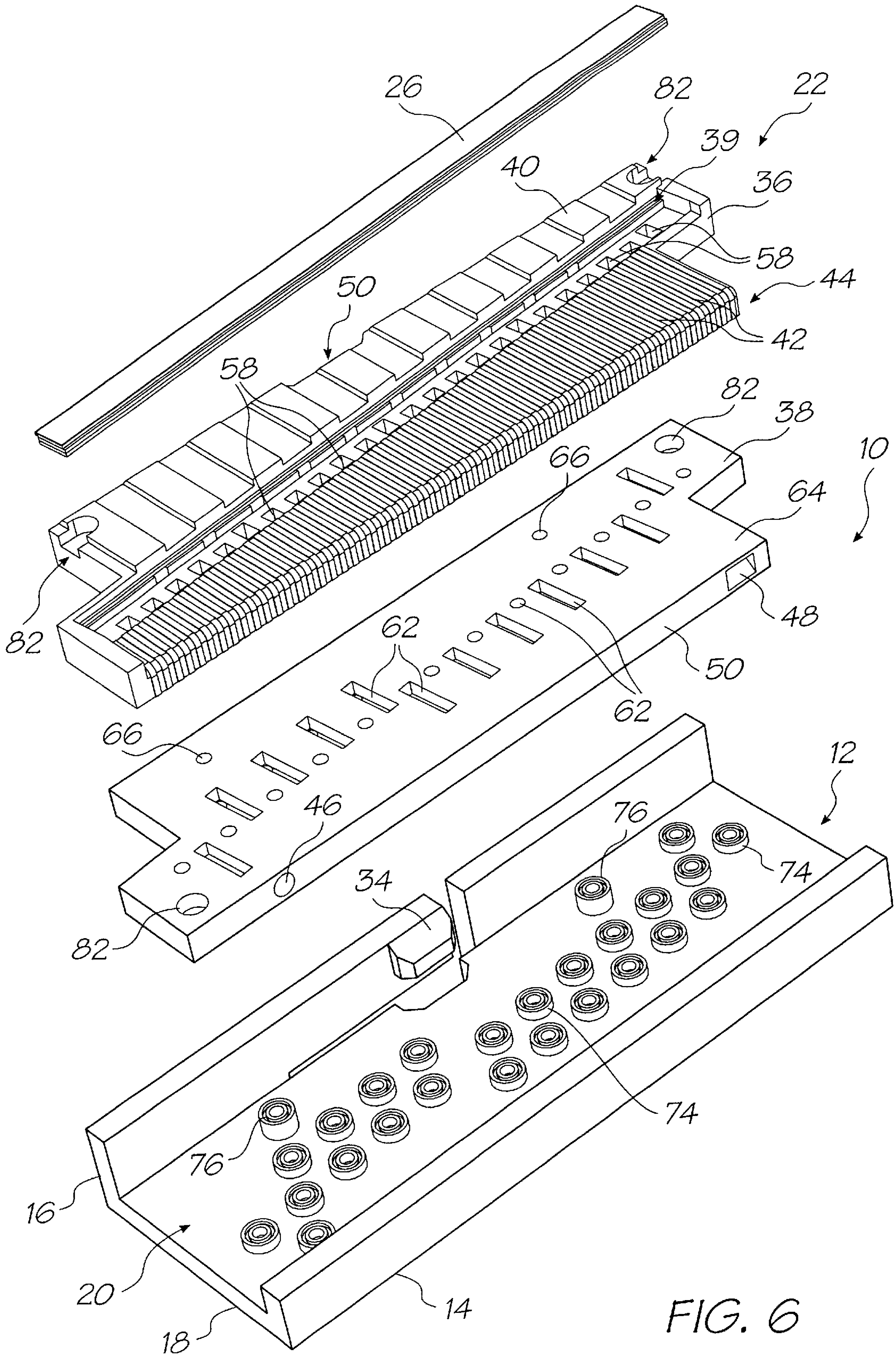


FIG. 5


26
82
22
39
40
36
58
50
44
42
58
82
38
66
10
64
48
82
62
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62
66
12
46
76
74
34
82
74
76
16
20
14
18

FIG. 6

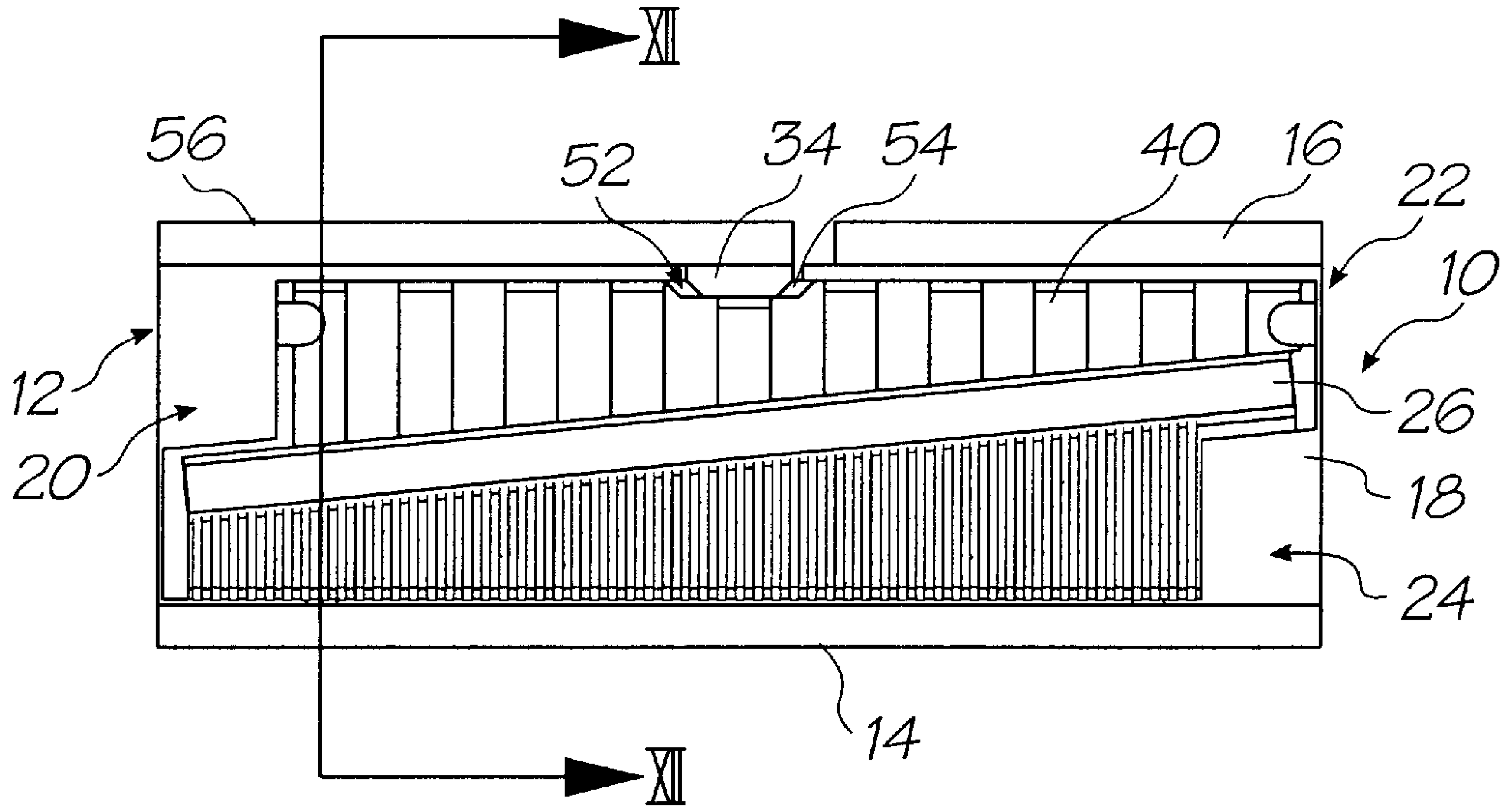


FIG. 7

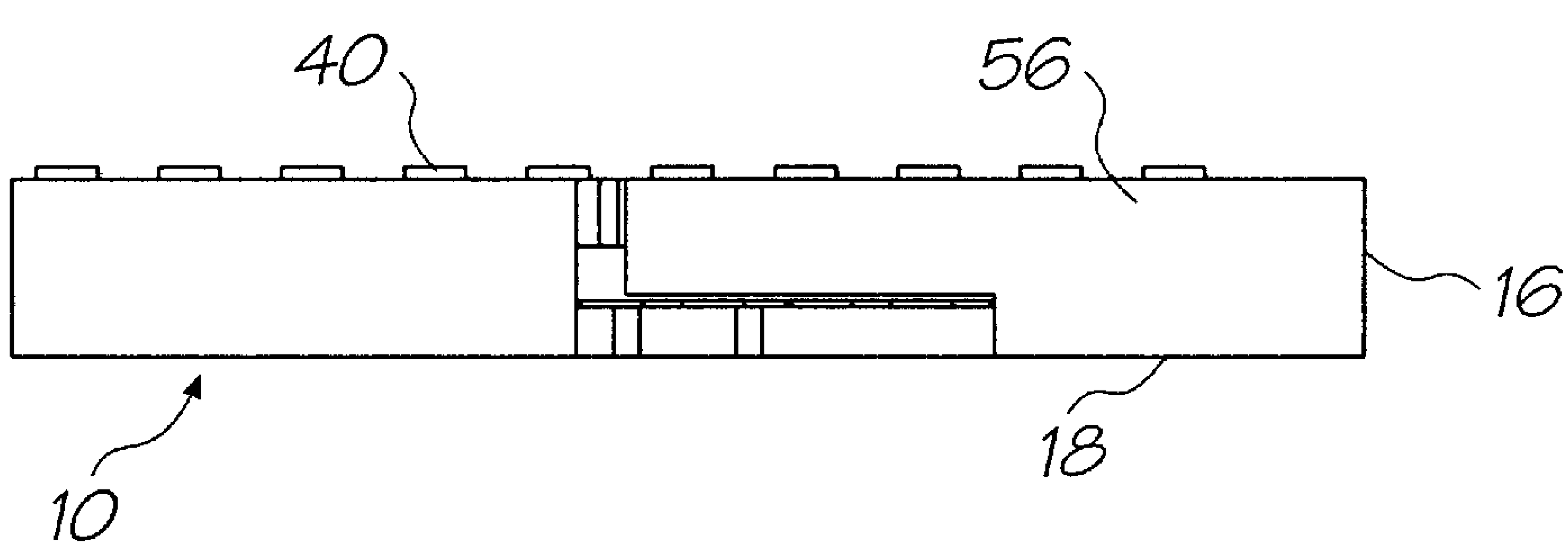


FIG. 8

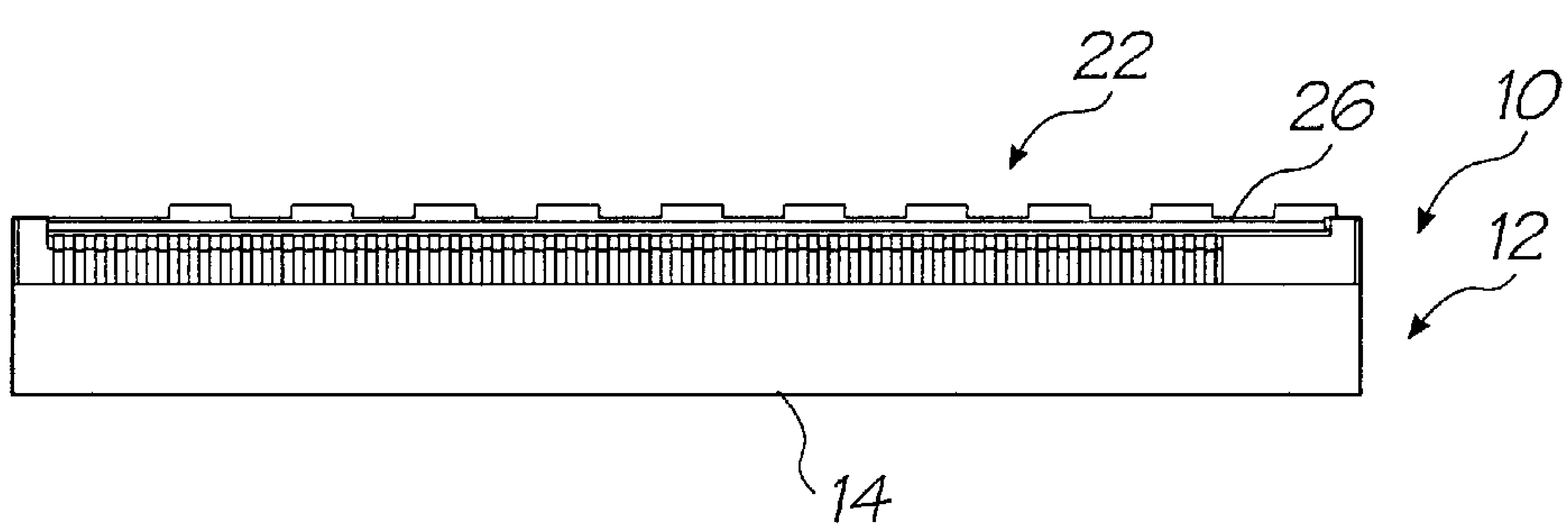


FIG. 9

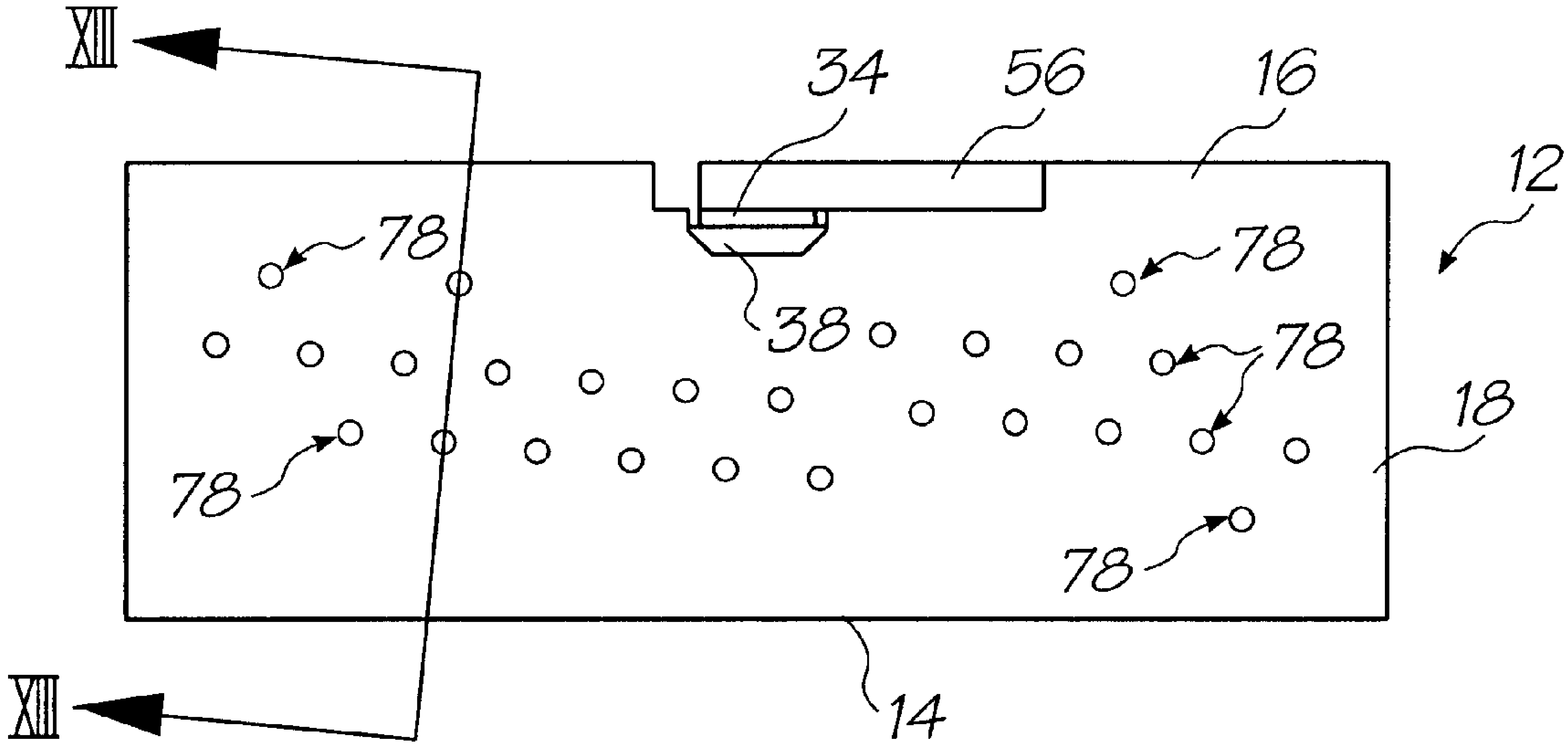


FIG. 10

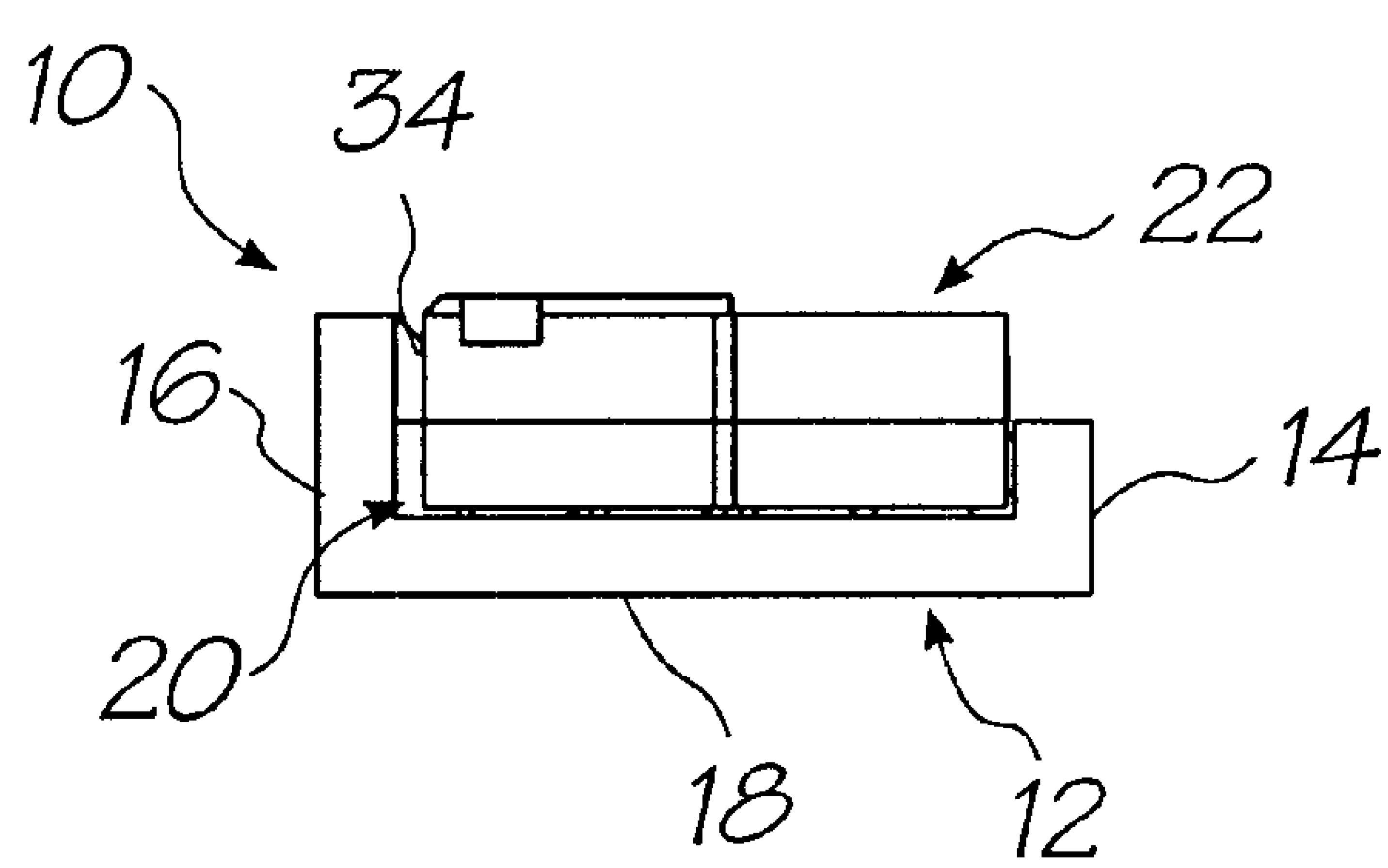


FIG. 11

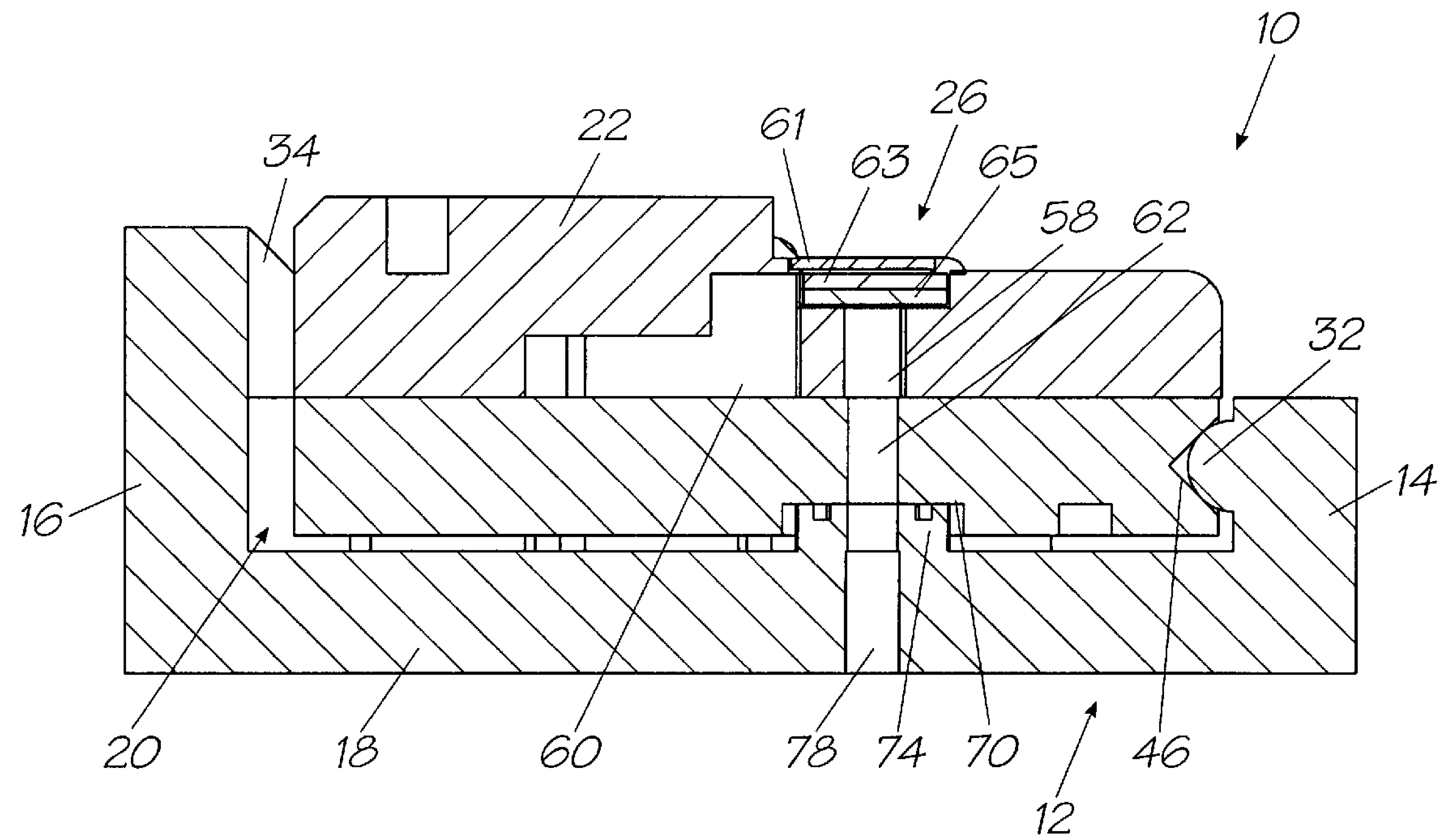
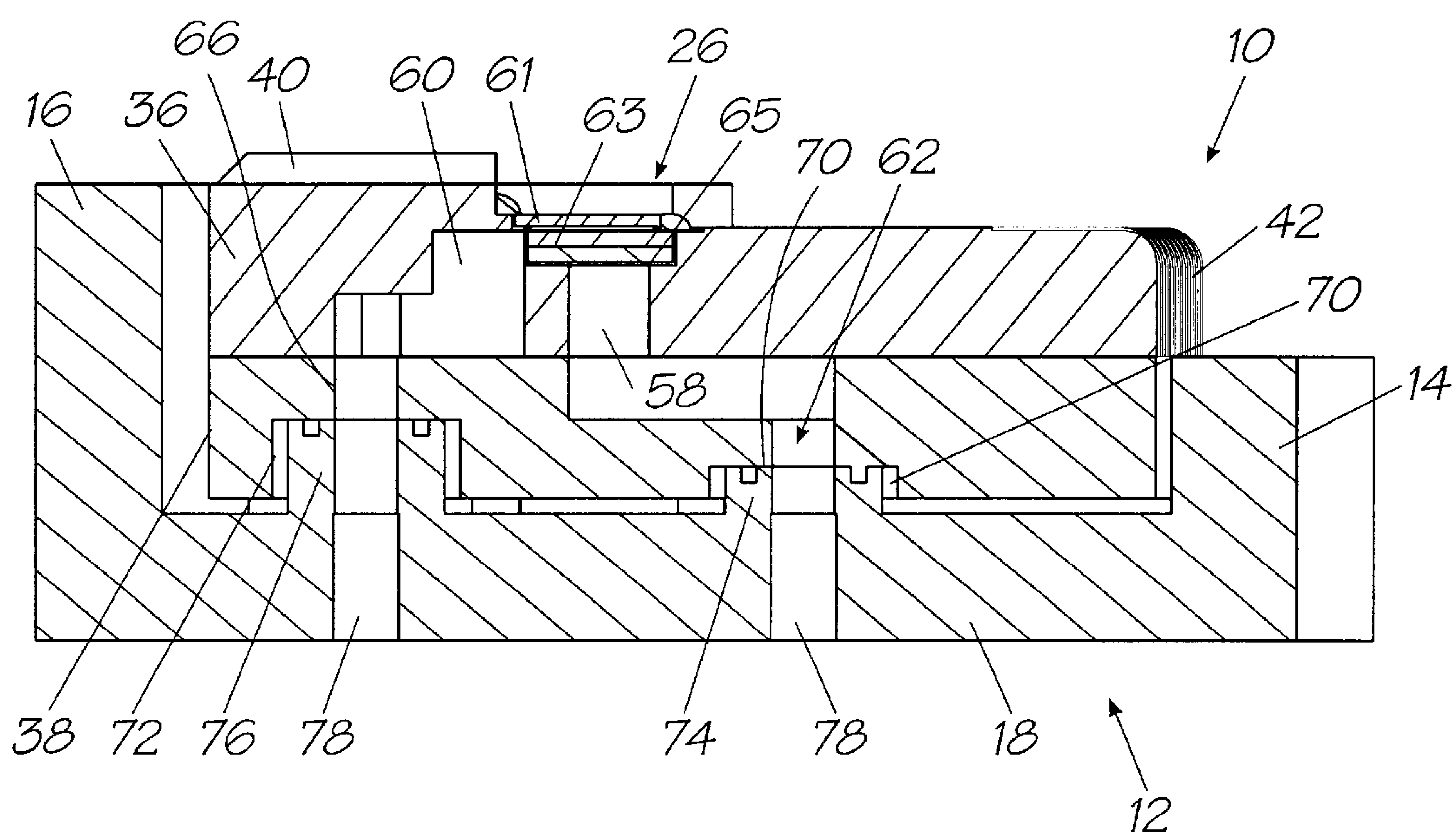

10
26
22
61
63
65
58
62
34
32
14
16
20
18
60
78
74
70
46
12

FIG. 12


66
40
60
61
26
10
16
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70
62
42
70
58
14
38
72
76
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74
78
18
12

FIG. 13

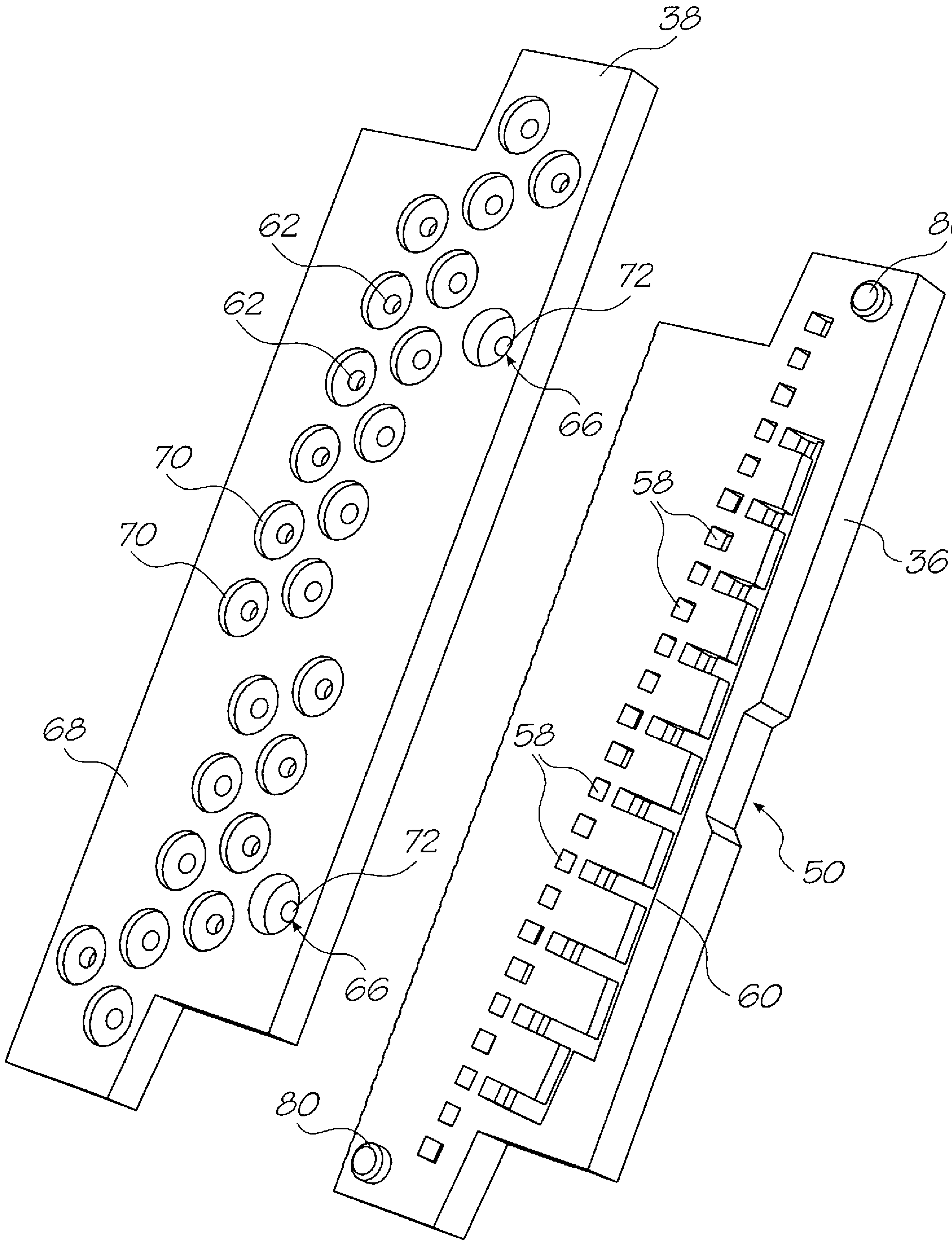
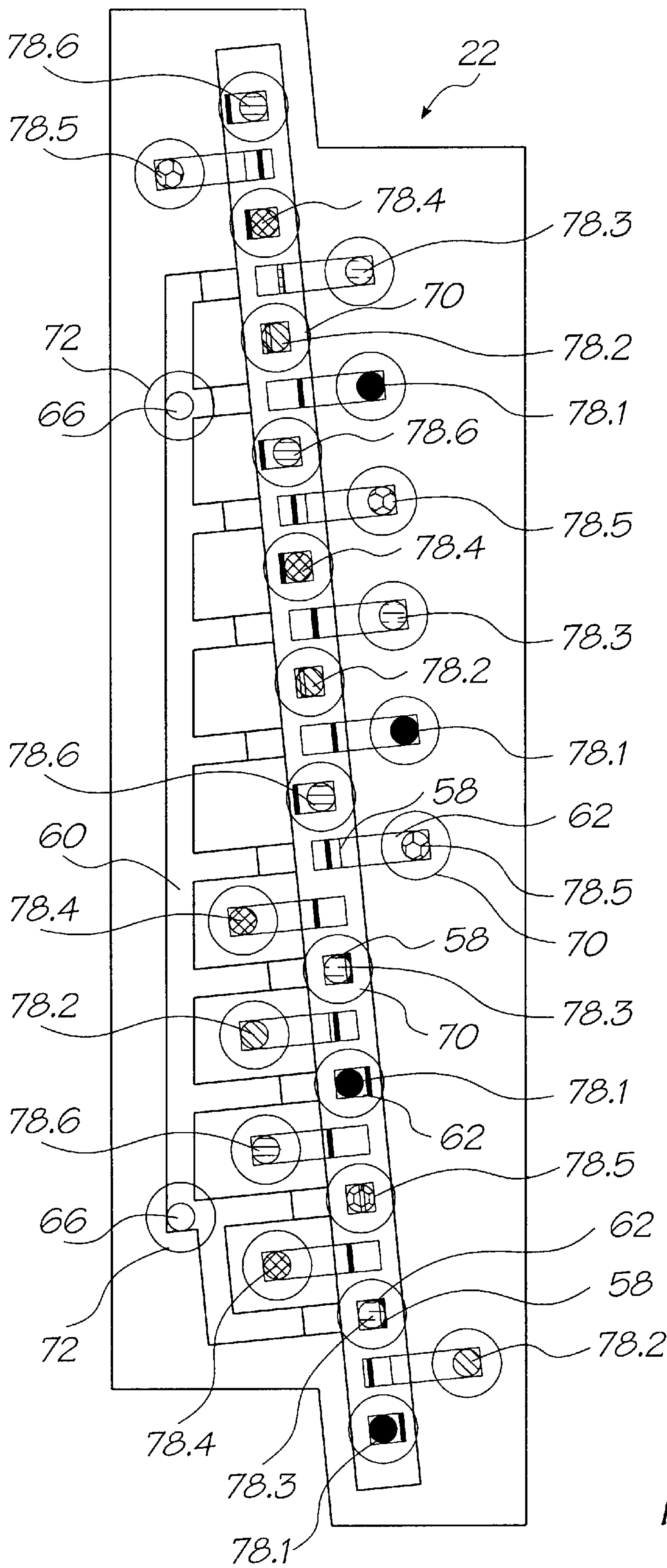


FIG. 14


22
78.6
78.5
78.4
78.3
70
72
78.2
66
78.1
78.6
78.5
78.4
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78.2
78.1
78.6
58
62
60
78.5
78.4
70
58
78.3
78.2
70
78.1
78.6
62
78.5
66
62
58
72
78.2
78.4
78.3
78.1

FIG. 15

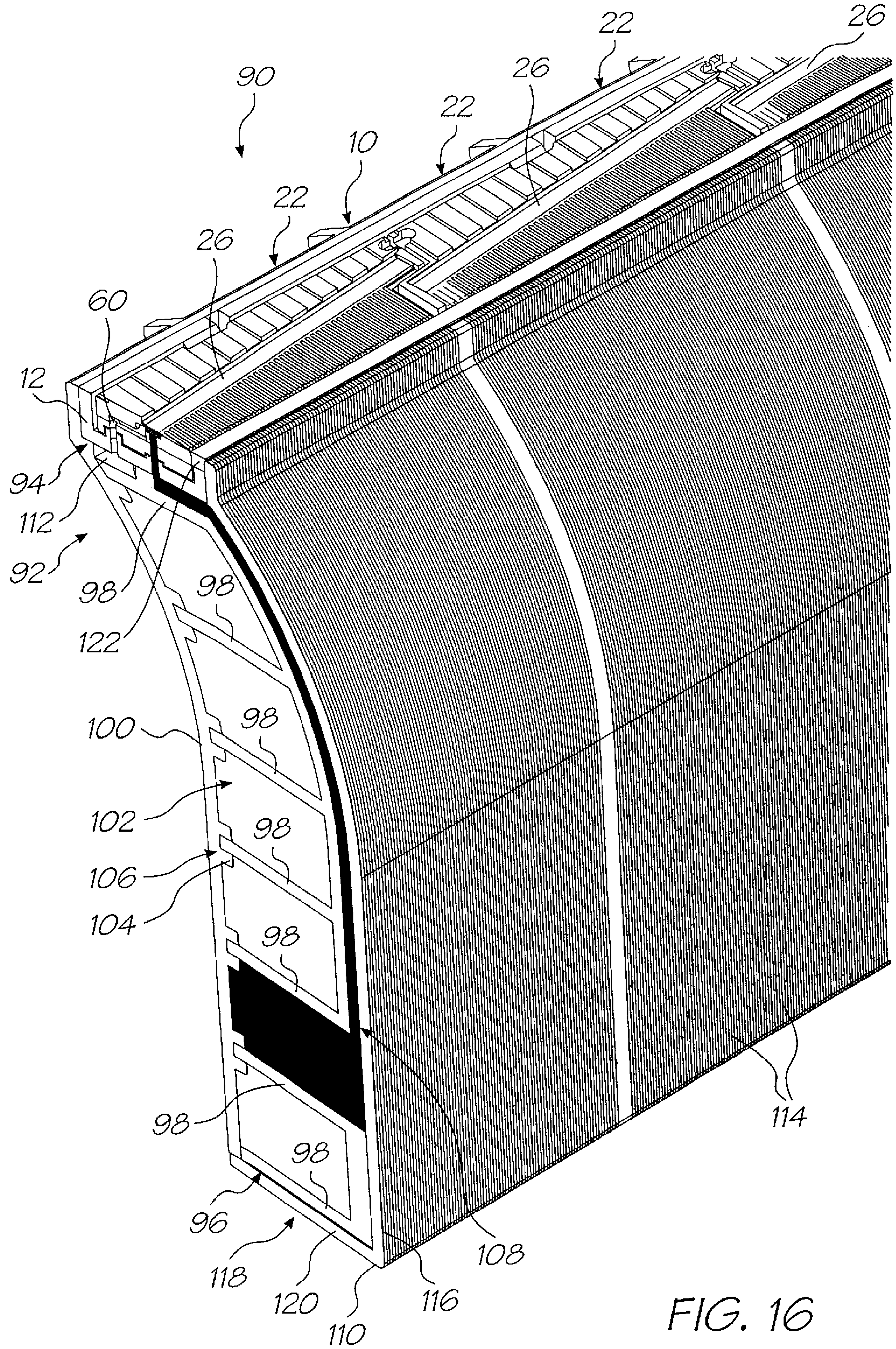
90
10
22
22
22
26
26
26
60
12
94
112
92
98
122
98
98
100
102
98
106
104
98
98
98
96
118
120
110
116
108
114

FIG. 16

METHOD OF ASSEMBLY OF SIX COLOR INKJET MODULAR PRINTHEAD

FIELD OF THE INVENTION

This invention relates to a modular printhead. More particularly, the invention relates to the assembly of such a modular printhead. Specifically, this invention relates to a method of assembling a printhead.

BACKGROUND OF THE INVENTION

The applicant has previously proposed the use of a pagewidth printhead to provide photographic quality printing. However, manufacturing such a pagewidth printhead having the required dimensions is problematic in the sense that, if any nozzle of the printhead is defective, the entire printhead needs to be scrapped and replaced.

Accordingly, the applicant has proposed the use of a pagewidth printhead made up of a plurality of small, replaceable printhead modules which are arranged in end-to-end relationship. The advantage of this arrangement is the ability to remove and replace any defective module in a pagewidth printhead without having to scrap the entire printhead.

It is also necessary to accommodate thermal expansion of the individual modules in the assembly constituting the pagewidth printhead to ensure that adjacent modules maintain their required alignment with each other.

SUMMARY OF THE INVENTION

According to the invention there is provided a method of assembling a printhead, the printhead having a receiving means and a plurality of printhead modules arranged end-to-end in the receiving means, the method comprising the steps of

upon completion of manufacturing of the receiving means, testing each bay of the receiving means in which a module will be received to determine a manufacturing offset from specification for that bay;

selecting a printhead module having a manufacturing offset from specification which accommodates the offset of the bay of the receiving means for which it has been selected; and

inserting the selected printhead into its associated bay of the receiving means.

The method may include, after manufacturing each printhead module, testing the printhead module to determine its manufacturing offset. Further, the method may include marking each tested printhead with its manufacturing offset.

The method may include storing all tested printhead modules having the same manufacturing offset together in a storage zone. Then, the step of selecting the printhead module may include removing the selected printhead module from its designated position in the storage zone.

The method may include using a statistical analysis process to ensure use of a very large majority of the modules. The applicant believes that, in fact, by use of the statistical analysis process, almost all the modules, if not all, will be used. The statistical analysis tool used may be a central limit theorem.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is now described by way of example with reference to the accompanying drawings in which:

FIG. **1** shows a three dimensional view of a multi-module printhead, in accordance with the invention;

FIG. **2** shows a three dimensional, exploded view of the printhead of FIG. **1**;

FIG. **3** shows a three dimensional view, from one side, of a mounting member of a printhead, in accordance with the invention;

FIG. **4** shows a three dimensional view of the mounting member, from the other side;

FIG. **5** shows a three dimensional view of a single module printhead, in accordance with the invention;

FIG. **6** shows a three dimensional, exploded view of the printhead of FIG. **5**;

FIG. **7** shows a plan view of the printhead of FIG. **5**;

FIG. **8** shows a side view, from one side, of the printhead of FIG. **5**;

FIG. **9** shows a side view, from an opposed side, of the printhead of FIG. **5**;

FIG. **10** shows a bottom view of the printhead of FIG. **5**;

FIG. **11** shows an end view of the printhead of FIG. **5**;

FIG. **12** shows a sectional end view of the printhead of FIG. **5** taken along line XII—XII in FIG. **7**;

FIG. **13** shows a sectional end view of the printhead of FIG. **5** taken along line XIII—XIII in FIG. **10**;

FIG. **14** shows a three dimensional, underside view of a printhead component;

FIG. **15** shows a bottom view of the component, illustrating schematically the supply of fluid to a printhead chip of the component; and

FIG. **16** shows a three dimensional, schematic view of a printhead assembly, including a printhead, in accordance with the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

A printhead, in accordance with the invention, is designated generally by the reference numeral **10**. The printhead **10** can either be a multi-module printhead, as shown in FIGS. **1** to **4** or a single module printhead as shown in FIGS. **5** to **15**. In practice, the printhead is likely to be a multi-module printhead and the illustrated, single module printhead is provided more for explanation purposes.

The printhead **10** includes a mounting member in the form of a channel shaped member **12**. The channel shaped member **12** has a pair of opposed side walls **14**, **16** interconnected by a bridging portion or floor portion **18** to define a channel **12**.

A plurality of printhead components in the form of modules or tiles **22** are arranged in end-to-end fashion in the channel **20** of the channel shaped member **12**.

As illustrated, each tile **22** has a stepped end region **24** so that, when adjacent tiles **22** are butted together end-to-end, printhead chips **26** of the adjacent tiles **22** overlap. It is also to be noted that the printhead chip **26** extends at an angle relative to longitudinal sides of its associated tile **22** to facilitate the overlap between chips **26** of adjacent tiles **22**. The angle of overlap allows the overlap area between adjacent chips **26** to fall on a common pitch between ink nozzles of the printhead chips **26**. In addition, it will be appreciated that, by having the printhead chips **26** of adjacent tiles **22** overlapping, no discontinuity of printed matter appears when the matter is printed on print media (not shown) passing across the printhead **10**.

If desired, a plurality of channel shaped members **12** can be arranged in end-to-end fashion to extend the length of the printhead **10**. For this purpose, a clip **28** and a receiving formation **30** (FIG. **4**) are arranged at one end of the channel shaped member **12** to mate and engage with corresponding formations (not shown) of an adjacent channel shaped member **12**.

Those skilled in the art will appreciate that the nozzles of the printhead chip have dimensions measured in micrometres. For example, a nozzle opening of each nozzle may be about **11** or **12** micrometres. To ensure photographic quality printing, it is important that the tiles **22** of the printhead **10** are accurately aligned relative to each other and maintain that alignment under operating conditions. Under such operating conditions, elevated temperatures cause expansion of the tiles **22**. It is necessary to account for this expansion while still maintaining alignment of adjacent tiles **22** relative to each other.

For this purpose, the channel shaped member **12** and each tile **22** have complementary locating formations for locating the tiles **22** in the channel **20** of the channel shaped member **12**. The locating formations of the channel shaped member **12** comprise a pair of longitudinally spaced engaging or locating formations **32** arranged on an inner surface of the wall **14** of the channel shaped member **12**. More particularly, each tile **22** has two such locating formations **32** associated with it. Further, the locating formations of the channel shaped member **12** include a securing means in the form of a snap release or clip **34** arranged on an inner surface of the wall **16** of the channel shaped member **12**. Each tile **22** has a single snap release **34** associated with it. One of the mounting formations **32** is shown more clearly in FIG. **12** of the drawings.

As shown most clearly in FIG. **6** of the drawings, each tile **22** includes a first molding **36** and a second molding **38** which mates with the first molding **36**. The molding **36** has a longitudinally extending channel **39** in which the printhead chip **26** is received. In addition, on one side of the channel **39**, a plurality of raised ribs **40** is defined for maintaining print media, passing over the printhead chip **26** at the desired spacing from the printhead chip **26**. A plurality of conductive ribs **42** is defined on an opposed side of the channel **39**. The conductive ribs **42** are molded to the molding **36** by hot stamping during the molding process. These ribs **42** are wired to electrical contacts of the chip **26** for making electrical contact with the chip **26** to control operation of the chip **26**. In other words, the ribs **42** form a connector **44** for connecting control circuitry, as will be described in greater detail below, to the nozzles of the chip **26**.

The locating formations of the tile **22** comprise a pair of longitudinally spaced co-operating elements in the form of receiving recesses **46** and **48** arranged along one side wall **50** of the second molding **38** of the tile **22**. These recesses **46** and **48** are shown most clearly in FIG. **6** of the drawings.

The recesses **46** and **48** each receive one of the associated locating formations **32** therein.

The molding **36** of the tile **22** also defines a complementary element or recess **50** approximately midway along its length on a side of the molding **36** opposite the side having the recesses **46** and **48**. When the molding **36** is attached to the molding **38** a stepped recess portion **52** (FIG. **7**) is defined which receives the snap release **34** of the channel shaped member **12**.

The locating formations **32** of the channel shaped member **12** are in the form of substantially hemispherical projections extending from the internal surface of the wall **14**.

The recess **46** of the tile **22** is substantially conically shaped, as shown more clearly in FIG. **12** of the drawings. The recess **48** is elongate and has its longitudinal axis extending in a direction parallel to that of a longitudinal axis of the channel shaped member **12**. Moreover, the formation **48** is substantially triangular, when viewed in cross section normal to its longitudinal axis, so that its associated locating formation **32** is slidably received therein.

When the tile **22** is inserted into its assigned position in the channel **20** of the channel shaped member **12**, the locating formations **32** of the channel shaped member **12** are received in their associated receiving formations **46** and **48**. The snap release **34** is received in the recess **50** of the tile **22** such that an inner end of the snap release **34** abuts against a wall **54** (FIG. **7**) of the recess **50**.

Also, it is to be noted that a width of the tile **22** is less than a spacing between the walls **14** and **16** of the channel shaped member **12**. Consequently, when the tile **22** is inserted into its assigned position in the channel shaped member **12**, the snap release **34** is moved out of the way to enable the tile **22** to be placed. The snap release **34** is then released and is received in the recess **50**. When this occurs, the snap release **34** bears against the wall **54** of the recess **50** and urges the tile **22** towards the wall **14** such that the projections **32** are received in the recesses **46** and **48**. The projection **32** received in the recess, locates the tile **22** in a longitudinal direction. However, to cater for an increase fin length due to expansion of the tiles **22**, in operation, the other projection **32** can slide in the slot shaped recess **48**. Also, due to the fact that the snap release **34** is shorter than the recess **50**, movement of that side of the tile **22** relative to the channel shaped member **12**, in a longitudinal direction, is accommodated.

It is also to be noted that the snap release **34** is mounted on a resiliently flexible arm **56**. This arm **56** allows movement of the snap release in a direction transverse to the longitudinal direction of the channel shaped member **12**. Accordingly, lateral expansion of the tile **22** relative to the channel shaped member **12** is facilitated. Finally, due to the angled walls of the projections **46** and **48**, a degree of vertical expansion of the tile **22** relative to the floor **18** of the channel shaped member **12** is also accommodated.

Hence, due to the presence of these mounting formations **32**, **34**, **46**, **48** and **50**, the alignment of the tiles **22**, it being assumed that they will all expand at more or less the same rate, is facilitated.

As shown more clearly in FIG. **14** of the drawings, the molding **36** has a plurality of inlet openings **58** defined at longitudinally spaced intervals therein. An air supply gallery **60** is defined adjacent a line along which these openings **58** are arranged. The openings **58** are used to supply ink and related liquid materials such as fixative or varnish to the printhead chip **26** of the tile **22**. The gallery **60** is used to supply air to the chip **26**. In this regard, the chip **26** has a nozzle guard **61** (FIG. **12**) covering a nozzle layer **63** of the chip **26**. The nozzle layer **63** is mounted on a silicon inlet backing **65** as described in greater detail in our co-pending application number U.S. Ser. No. 09/608,779, entitled “An ink supply assembly for a print engine” (Docket Number: CPE02). The disclosure of this co-pending application is specifically incorporated herein by cross-reference.

The opening **58** communicates with corresponding openings **62** defined at longitudinally spaced intervals in that surface **64** of the molding **38** which mates with the molding **39**. In addition, openings **66** are defined in the surface **64** which supply air to the air gallery **60**.

As illustrated more clearly in FIG. **14** of the drawing, a lower surface **68** has a plurality of recesses **70** defined therein into which the openings **62** open out. In addition, two further recesses **72** are defined into which the openings **66** open out.

The recesses **70** are dimensioned to accommodate collars **74** standing proud of the floor **18** of the channel shaped member **12**. These collars **74** are defined by two concentric annuli to accommodate movement of the tile **22** relative to the channel **20** of the channel shaped member **12** while still ensuring a tight seal. The recesses **66** receive similar collars **76** therein. These collars **76** are also in the form of two concentric annuli.

The collars **74, 76** circumscribe openings of passages **78** (FIG. **10**) extending through the floor **18** of the channel shaped member **12**.

The collars **74, 76** are of an elastomeric, hydrophobic material and are molded during the molding of the channel shaped member **12**. The channel shaped member **12** is thus molded by a two shot molding process.

To locate the molding **38** with respect to the molding **36**, the molding **36** has location pegs **80** (FIG. **14**) arranged at opposed ends. The pegs **80** are received in sockets **82** (FIG. **6**) in the molding **38**.

In addition, an upper surface of the molding **36**, i.e. that surface having the chip **26**, has a pair of opposed recesses **82** which serve as robot pick-up points for picking and placing the tile **22**.

A schematic representation of ink and air supply to the chip **26** of the tile **22** is shown in greater detail in FIG. **15** of the drawings.

Thus, via a first series of passages **78.1** cyan ink is provided to the chip **26**. Magenta ink is provided via passages **78.2**, yellow ink is provided via passages **78.3**, and black ink is provided via passages **78.4**. An ink which is invisible in the visible spectrum but is visible in the infrared spectrum is provided by a series of passages **78.5** and a fixative is provided via a series of passages **78.6**. Accordingly, the chip **26**, as described, is a six "color" chip **26**.

To cater for manufacturing variations in tolerances on the tile **22** and the channel shaped member **12**, a sampling technique is used.

Upon completion of manufacture, each tile **22** is measured to assess its tolerances. The offset from specification of the particular tile **22** relative to a zero tolerance is recorded and the tile **22** is placed in a bin containing tiles **22** each having the same offset. A maximum tolerance of approximately +10 microns or −10 microns, to provide a 20 micron tolerance band, is estimated for the tiles **22**.

The storage of the tiles **22** is determined by a central limit theorem which stipulates that the means of samples from a non-normally distributed population are normally distributed and, as a sample size gets larger, the means of samples drawn from a population of any distribution will approach the population parameter.

In other words, the central limit theorem, in contrast to normal statistical analysis, uses means as variates themselves. In so doing, a distribution of means as opposed to individual items of the population is established. This distribution of means will have its own mean as well its own variance and standard deviation.

The central limit theorem states that, regardless of the shape of the original distribution, a new distribution arising from means of samples from the original distribution will result in a substantially normal bell-shaped distribution curve as sample size increases.

In general, variants on both sides of the population mean should be equally represented in every sample. As a result, the sample means cluster around the population mean. Sample means close to zero should become more common as the tolerance increases regardless of the shape of the distribution which will result in a symmetrical uni-modal, normal distribution around the zero positions.

Accordingly, upon completion of manufacture, each tile **22** is optically measured for variation between the chip **26** and the moldings **36, 38**. When the tile assembly has been measured, it is laser marked or bar coded to reflect the tolerance shift, for example, +3 microns. This tile **22** is then placed in a bin of +3 micron tiles.

Each channel **12** is optically checked and the positions of the locating formations **32, 34** noted. These formations may be out of alignment by various amounts for each tile location or bay. For example, these locating formations **32, 34** may be out of specification by −1 micron in the first tile bay, by +3 microns in the second tile bay, by −2 microns in the third tile bay, etc.

The tiles **22** will be robot picked and placed according to the offsets of the locating formations **32, 34**. In addition, each tile **22** is also selected relative to its adjacent tile **22**.

With this arrangement, variations in manufacturing tolerances of the tiles **22** and the channel shaped member **12** are accommodated such that a zero offset mean is possible by appropriate selections of tiles **22** for their locations or bays in the channel shaped member **12**.

A similar operation can be performed when it is desired or required to replace one of the tiles **22**.

Referring now to FIG. **16** of the drawings, a printhead assembly, also in accordance with the invention, is illustrated and is designated generally by the reference numeral **90**. The assembly **90** includes a body member **92** defining a channel **94** in which the printhead **10** is receivable.

The body **92** comprises a core member **96**. The core member **96** has a plurality of channel defining elements or plates **98** arranged in parallel spaced relationship. A closure member **100** mates with the core member **96** to close off channels defined between adjacent plates to form ink galleries **102**. The closure member **100**, on its operatively inner surface, has a plurality of raised rib-like formations **104** extending in spaced parallel relationship. Each rib-like member **104**, apart from the uppermost one (i.e. that one closest to the channel **94**) defines a slot **106** in which a free end of one of the plates **98** of the core member **96** is received to define the galleries **102**.

A plurality of ink supply canals are defined in spaced parallel relationship along an operatively outer surface of the core member **96**. These canals are closed off by a cover member **110** to define ink feed passages **108**. These ink feed passages **108** open out into the channel **94** in communication with the passages **78** of the channel shaped member **12** of the printhead **10** for the supply of ink from the relevant galleries **102** to the printhead chip **26** of the tiles **22**.

An air supply channel **112** is also defined beneath the channel **94** for communicating with the air supply gallery **60** of the tiles **22** for blowing air over the nozzle layer **63** of each printhead chip **26**.

In a similar manner to the conductive ribs **42** of the tile **22**, the cover member **110** of the body **92** carries conductive ribs **114** on its outer surface **116**. The conductive ribs **114** are also formed by a hot stamping during the molding of the cover member **110**. These conductive ribs **114** are in electrical contact with a contact pad (not shown) carried on an outer surface **118** of a foot portion **120** of the printhead assembly go.

When the printhead **10** is inserted into the channel **94**, the conductive ribs **42** of the connector **44** of each tile **22** are placed in electrical contact with a corresponding set of conductive ribs **114** of the body **92** by means of a conductive strip **122** which is placed between the connector **44** of each tile **22** and the sets of ribs **114** of the body **92**. The strip **122** is an elastomeric strip having transversely arranged conductive paths (not shown) for placing each rib **42** in electrical communication with one of the conductive ribs **114** of the cover member **110**.

Accordingly, it is an advantage of the invention that a printhead **10** is provided which is modular in nature, can be rapidly assembled by robotic techniques, and in respect of which manufacturing tolerances can be taken into account to facilitate high quality printing. In addition, a printhead assembly go is also able to be manufactured at high speed and low cost.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

We claim:

1. A method of assembling a printhead, the printhead having a receiving means and a plurality of printhead modules arranged end-to-end in the receiving means, the method comprising the steps of

upon completion of manufacturing of the receiving means, testing each bay of the receiving means in which a module will be received to determine a manufacturing offset from specification for that bay;

selecting a printhead module having a manufacturing offset from specification which accommodates the offset of the bay of the receiving means for which it has been selected; and

inserting the selected printhead into its associated bay of the receiving means.

2. The method of claim **1** which includes, after manufacturing each printhead module, testing the printhead module to determine its manufacturing offset.

3. The method of claim **2** which includes marking each tested printhead with its manufacturing offset.

4. The method of claim **3** which includes storing all tested printhead modules having the same manufacturing offset together in a storage zone.

5. The method of claim **4** in which the step of selecting the printhead module includes removing the selected printhead module from its designated position in the storage zone.

6. The method of claim **1** which includes using a statistical analysis process to ensure use of a very large majority of the modules.

7. The method of claim **6** which includes using a central limit theorem as a statistical analysis tool.

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